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IMPROVED COMPRESSIVE STRENGTH OF CONCRETE WITH SAW DUST ASH AS PARTIAL REPLACEMENT FOR CEMENT USING RE-VIBRATION

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Abstract. The use of re-vibration is employed to improve the compressive strength of concrete with Saw Dust Ash (SDA) as partial replacement for cement in concrete production as presented. A mix ratio of 1:2:4 and water cement ratio of 0.6 was used to cast a total of 42 cubes specimen. Seven (7) concrete cubes were cast each for 0 % using 5 %, 10 %, 15 %, 20 % and 25 % replacements of cement with SDA respectively. The cubes were cured for 28 days and their compressive strength determine by crushing. Result obtained shows that the optimum SDA replacement was 10 % with a compressive strength of 21.67 N/mm2 at 28 days. It therefore means that SDA can partially replace cement up to 10 % and re-vibration can be utilize to improve the concrete strength once done within the setting time and plastic range of the fresh concrete.

Keywords: agro-wastes, concrete, compressive strength, pozzolana, re-vibration, sawdust ash.

1.0 Introduction.

In view of the need for alternative construction and building materials many researchers have suggested chemical additives, pozzolanas from agro-wastes and now re-vibration technics to improve on concrete strength to still deliver the same and at times even better serviceability than the conventional concrete. Saw dust is a waste material from the timber industry; it is produced as timber is sawn into planks at saw mills located in virtually all major towns in the country.

The need to convert this waste product into a useful by-product is the focus of the study. Some industrial wastes have been studied for use as supplementary cementing materials such as volcanic ash [1], Rice husk ash [2] and some Nigerian agro-wastes [3].

Initial vibration of concrete may not totally eliminate defect, such as honey comb and void leading to reduction in the strength and performance. Since early days many civil engineers are of the opinion that partially set concrete should not be disturbed strong belief has it that any disturbance to concrete, like re-vibration in the initial setting stage makes the concrete deteriorate and lose its strength [4]. However, it is suggested that re-vibration eliminate defect, honey comb and void there by increasing the compressive strength of the concrete [4] and [5]. Re-vibration of concrete is the process of again vibrating the place concrete intentionally and systematically, sometime after the initial consolidation is completed a proper executed re-vibration result improved concrete quality, that is, increasing the strength and bond, better impermeability, reduction in shrinkage and creep, reduction in surface and other void as well as crack in fresh concrete and so on [4; 5] and [2].

[6] investigate the effect of induced vibration on early age concrete and concluded that re-vibrating soil after compaction does not negatively affect the attainable compressive strength of a concrete although it may have a slight negative effect on the tensile capacity, the effect can be reasonably assumed to be negligible [4] examined the effect of re-vibration on compressive strength of a concrete and concluded that re-vibration resulted in the enhancement of compressive strength when carried out within plastic range, increases compressive strength. Re-vibration is beneficial, provided the already placed & compacted concrete can regain plastic state under re-vibration.

The aim of this study is investigate the effect of re-vibration on the compressive strength of concrete using saw dust ash (SDA) as partial replacement for cement. To achieve this, the following objectives would be undertaken:

1. To undertake the preliminary tests of aggregate and chemical properties test of saw dust ash (SDA);
2. To cast 42 cube specimens with 7cubes each for each percentage replacements (0%, 5%, 10%, 15%, 20% and 25%);
3. The re-vibrating all categories of percentage replacements at 10minutes successions up to 1hour and cure for only 28-days;
4. To determine the compressive strength of each cube by crushing;

2.0 Materials and Methods.

2.1 Materials and equipment.

The material used for the research work are, Portland cement, fine aggregate, coarse aggregate, sawdust ash, water. The equipment used for the practical includes 20 mm mesh (sieve) 5 mm mesh (BS sieves) and set of sieves of various sizes. Weighing balance, tray, mould, shovel and trowel, tapping rod, table vibrator and curing tank.

2.2 Tests.

The test carried on SDA was chemical test. The saw dust was first burnt in a closed temperature regulated incinerator. After which the ash was generated, and sieved with sieve 75 µm. Sample of the ash was taken to the laboratory and was put into the X-ray diffraction machine and the weight of the oxides were generated. Other tests carried out included: moisture content, specific gravity of SDA, fine aggregate, coarse aggregate and slump test of the fresh concrete. All were carried out according to specifications [7; 8].

2.3 Preparations of Concrete cubes specimens.

The required forty-two (42) cube specimens were cast of sizes 150 mmx150 mmx150 mm of mix design 1:2:4 with 0.5 water cement ratio. After the casting of the cubes of various percentage replacements 90 %, 5 %, 10 %, 15 %, 20 % and 25 %) of SDA for cement, they were all revibrated using the table vibrator at 10minutes interval through 1-hour period of successive revibration time lag intervals. All the 42 cubes were left for 24hr to solidify after which they were de-molded and put into the curing tank to be cure for 28 days according to specifications. After the 28 days curing of the 42 cubes, each of the cubes was put into the compressive testing machine to be crushed in order to determine the strength of the concrete [9].

3.0 Results and Discussions.

3.1 Chemical analysis of SDA.

The physical and chemical properties of SDA used in this study are shown in table 1. It is seen that the SDA proportion of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3) and iron oxide (Fe_2O_3) when combined together was 62.26 %, which is slightly below the 70 % of specified by [10] for pozzolana.

Table 1.

Chemical Composition of Saw Dust Ash (SDA)

Element	Concentration
Na_2O	5.970wt%
MgO	11.136wt%
Al_2O_3	19.770wt%
SiO_2	36.005wt%
P_2O_5	6.532wt%
K_2O	13.965wt%
CaO	20.063wt%
TiO_2	0.629wt%
Fe_2O_3	6.486wt%

Specific gravity of SDA: The average specific gravity of SDA was 2.55 through three trials. Since the weight of the ash with specific gravity of 2.55 is far less than the weight of cement of 3.15, as such is and inevitable reduction in the weight of OPC – SDA concrete cubes was observed.

Bulk density of SDA: The test was carried out with three trials each for the compacted has an average value of 699. The uncompacted has 576. The ratio of the uncompacted to compacted gives 0.82.

Water adsorption of SDA: The average adsorption for the SDA is 170.4. Also from the result it can be observe that the value of the dry ash from all the trials increased drastically from 7.9 to 14.9, 3.3 to 5.7 and 3.4 to 5.1, this shows that saw dust ash as a great ability to hold water.

Particle size distribution of SDA used: From Table 2, the Fineness Modulus of the SDA is computed as FM = 1.78. The FM of SDA is less than 2.3–3.1 suggested [10] for aggregates. Fineness Modulus result of 1.38 submitted by [3].

Table 2.

Particle size analysis of SDA

Sieve size (mm)	Weight retain (g)	Percentage retain %	Cumulative percentage retain %	Cumulative percentage passing %
4.75 mm	0.00	0.00	0.00	100.0
3.35 mm	0.00	0.00	0.00	100.0
2.0 mm	0.00	0.00	0.00	100.0
1.18 mm	0.00	0.00	0.00	100.0
850 mm	0.00	0.00	0.00	100.0
600µm	0.00	0.00	0.00	100.0
425µm	0.00	0.00	0.00	100.0
300µm	39.2	19.6	19.6	80.4
150µm	98.4	49.2	67.8	32.2
75µm	45.7	23.38	91.18	8.82
Pan	44.2	22.1	-	-
Total			178.58	

Particle Size Distribution: From Figure 1, grain size corresponding to 60 % (D60), 10 % (D10) and 30 % (D30) passing the sieve is 0.60 mm, 0.1 mm and 0.38 mm respectively .therefore, the uniformity coefficient Cu is to be 6.0. However, the coefficient Cc is calculated using =2.4. Hence the aggregate is well graded sand. This result agrees with the Unified Soil Classification System (USCS) well graded sand with less than 5 % fine has $Cu \geq 6$ and $1 \leq Cc \leq 3$ as stated by Arora (2010).

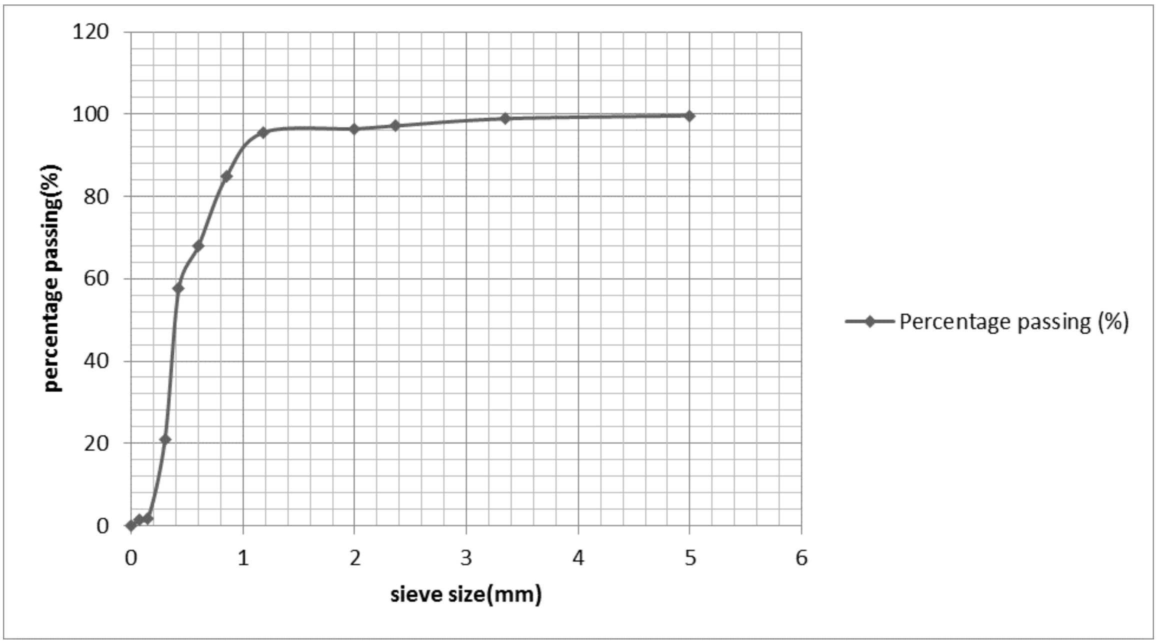

Figure 1. Particle Size Distribution Curve for fine Aggregates

Particle size distribution curve of coarse aggregates: From figure 2, grain size corresponding to 60 % (D60), 10 % (D10) and 30 % passing the sieve is 14.0mm 10.0mm and 12.0mm respectively. Therefore, the uniformity coefficient Cu is calculated to be 1.40. However, the coefficient Cc is calculated using 1.02. Hence the aggregate is well graded gravel. This result agrees with the Unified Soil Classification System (USCS).

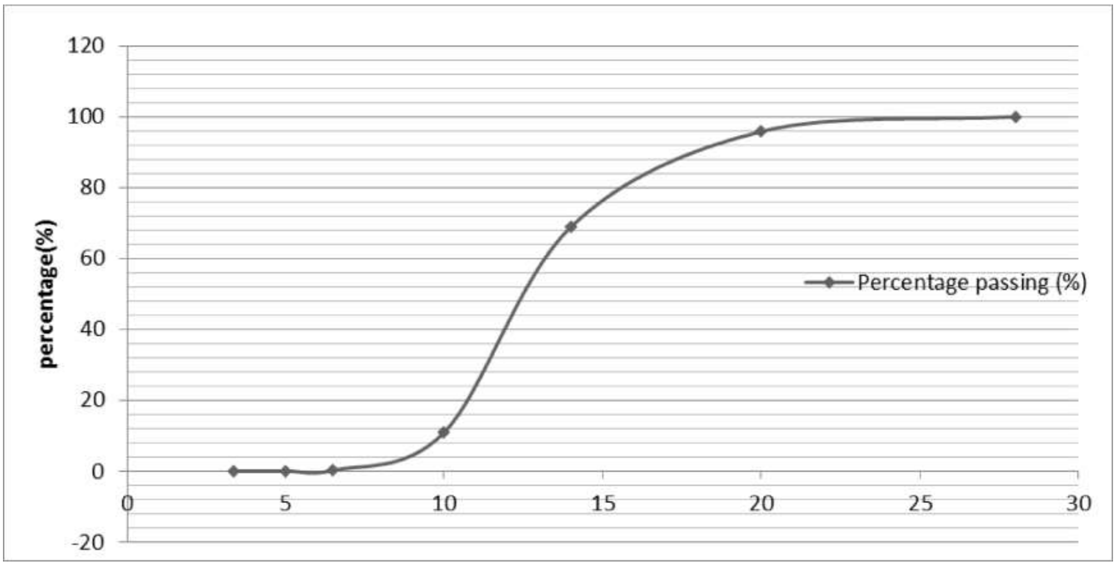

Figure 2. Particle size distribution curve for coarse aggregates

Slump: The slump of the freshly prepared concrete with various percentage replacements of SDA for cement are presented on Table 3.

Workability can be define as that property of freshly mixed concrete or mortar that determines the ease and homogeneity with which it can be mixed, placed, compacted and finished to a homogenous condition. Water content, cement content and to cement ratio are some of the factor that affect the workability of the fresh concrete.

Table 3.

Slump Test of the fresh concrete

Percentage replacement of SDA for OPC	Slump (mm)
0 %	61
5 %	59
10 %	58
15 %	56
20 %	52
25 %	45

The result shows that the slump and the compacting factor decreased upon the addition of SDA as partial replacement for OPC. It was observe that the slump for OPC (0 %) is 61mm and this value decreases from 5 % (51mm) replacement till 25 % (45 mm) replacement of SDA.

3.2 Effect of re-vibration on the compressive strength of concrete at 28 days curing

The compressive strength of OPC-SDA concrete and the effect of re-vibration were investigated at 28-days curing age only. The result is presented on Table 4 and Figure 3.

Table 4.

Compressive strength of the concrete at different percentage replacement

Percentage replacement	Specimen	Time (minutes)	Weight (Kg)	Strength (KN)	Compressive strength (N/mm^2)
0 % SDA + 100 %OPC	1	0	7.98	666.90	29.04
	2	10	8.07	679.95	30.22
	3	20	8.30	679.90	30.20
	4	30	7.95	654.17	29.64
	5	40	8.07	654.07	29.16
	6	50	8.06	618.08	27.47
	7	60	8.23	618.00	27.47

5 % SDA + 95 %OPC	1	0	8.47	666.9	29.07
	2	10	8.43	690.0	30.66
	3	20	8.32	660.0	29.33
	4	30	8.78	610.0	29.64
	5	40	8.31	630.0	29.17
	6	50	8.24	670.0	27.47
	7	60	8.36	600.0	26.67
10 %SDA + 90 %OPC	1	0	8.01	486	20.58
	2	10	8.17	490	21.67
	3	20	8.26	472	21.60
	4	30	8.37	462	20.50
	5	40	8.20	460	20.35
	6	50	8.08	458	20.44
	7	60	8.16	420	18.67
15 %SDA + 85 % OPC	1	0	8.19	458	20.36
	2	10	8.01	470	20.68
	3	20	8.15	412	18.40
	4	30	8.28	404	17.56
	5	40	8.14	394	17.30
	6	50	8.41	370	16.44
20 %SDA + 80 % OPC	1	0	7.96	404	17.55
	2	10	8.19	420	18.67
	3	20	8.40	394	17.55
	4	30	8.01	392	17.42
	5	40	7.84	370	16.44
	6	50	8.15	360	16.00
	7	60	7.87	344	15.29
25 %SDA + 75 % OPC	1	0	8.16	386	14.13
	2	10	8..47	288	17.24
	3	20	8.14	370	17.15
	4	30	7.15	318	16.44
	5	40	8.49	298	13.24
	6	50	8.17	296	13.15
	7	60	8.30	290	12.69

Figure 3 shows the variation of compressive strength with percentage replacement, saw dust ash replacement in the mix. The result shows at 28 days of curing. The control (0 %) concrete developed a maximum comprehensive strength of 30.22 N/mm^2. With the inclusion of the SDA, there was a slight increase the strength of the concrete at 5 % replacement, the maximum strength at 5 % gives 30.66 N/mm^2. Getting to 10 % replacement it was observed that there was a drastic reduction in the strength to 21.67 N/mm^2 compare to the maximum strength of the 0%. At 10 % replacement concrete with this strength (21.67 N/mm^2) can still be used for construction work.

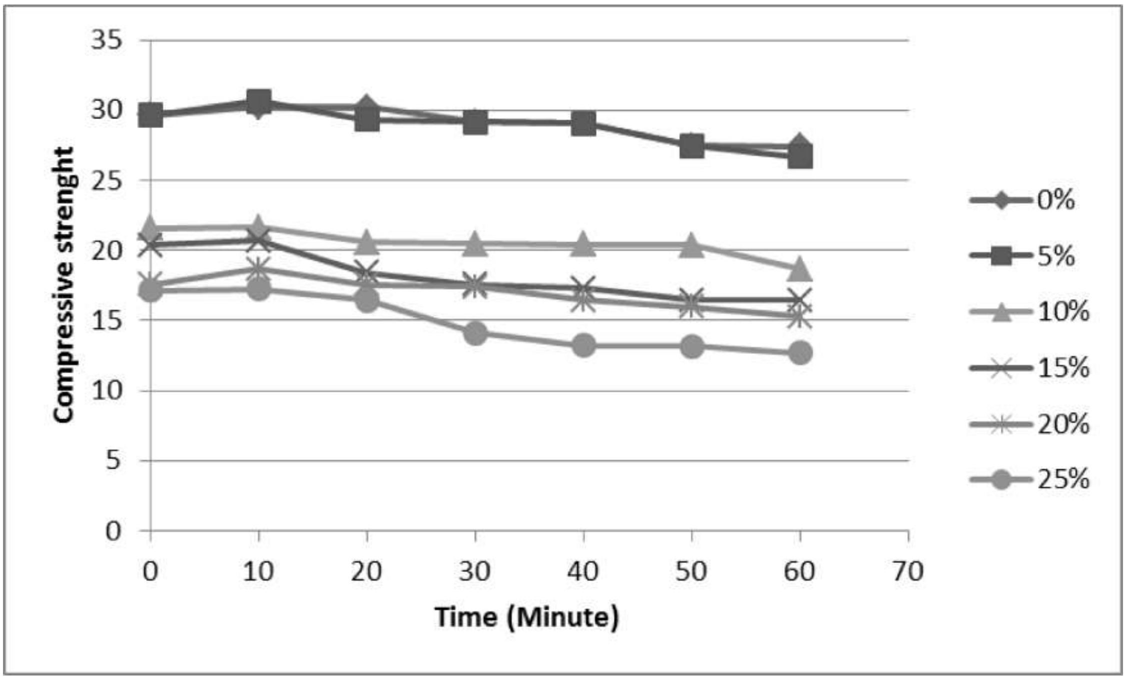

Figure 3. Compressive Strength of Concrete with re-vibration time lag

Considering the 15 % replacement which gives maximum strength of 20.68 N/mm^2, this also shows a decrease in the strength compare to 10 % replacement. Also 20 % replacement and 25 % replacement shows a high reduction at their maximum strength 18.67 N/mm^2, 17.24 N/mm^2 compare to the strength of the control. This reduction in strength may be due to the excess of silicate oxide added to the mix as the percentage replacement increases; concrete with this strength is not advisable to be use in any construction work because it possesses a weaker strength.

Therefore this result reveals that concrete with SDA replacement cured for 28 days improve the strength up to 10 % replacement of OPC with SDA. Hence, the optimum replacement level of OPC by SDA to give maximum long term strength is seen to be at 10 %. However, as the percentage of SDA content increases beyond 10 %, the compressive strength of the concrete cube specimens decreases. This is in agreement with [11] research on SDA which suggests 10 % replacement cement as optimal.

Considering the effect of re-vibration on the compressive strength of the concrete obtained in this study, it was observe that at 0 minute re-vibration of 0 % the strength was 29.04 N/mm^2 when it was revibrated after 10minute of casting the strength increases to 30.22 N/mm^2, this result shows that re-vibration increases the strength of concrete when done within the initial setting time of the concrete. The strength of the concrete begins to decrease when revibrated from 20 minutes to 60 minutes of casting because it is losing its plasticity.

The result also reveals that there was an increase in the strength at 5 % replacement of SDA. The strength at 5 % of OPC-SDA gives 29.07 N/mm^2 it also increases at 10 minutes re-vibration time lag to 30.66 N/mm^2. Further increment in the re-vibration time lag shows a decrease in the strength of the concrete. All the strength values obtained at each replacement are seemingly maxima at 10 minutes revibration time lag.

Therefore, the result shows that re-vibration enhances the compressive strength of OPC and OPC-SDA concrete. This result is similar to the findings of [2; 4] and [5] which state that re-vibration increases the compressive strength of concrete if carried out within the initial setting time of the concrete. The result also show that re-vibration of OPC-SDA concrete within the first 60minutes produced a higher strength than the non revibrated OPC-SDA concrete. This corresponded with the conclusion of [5] that re-vibration has the ability to increase the compressive strength as long as it is done when the mix can be brought back to plastic state [6] induced vibration appears to increase the compressive strength of the concrete in both 7 and 28 days compression test.

5.0 Conclusions and Recommendations.

Effect of re-vibration on the compressive strength of the concrete using saw dust ash as partial replacement for cement is presented. From this study, the following conclusion can be made:

1. SDA used in this study contained 36.005 % of silicon oxide (SiO_2) which enables it to react well with the lime from hydrated OPC from calcium silicate compound the compressive strength of concrete. It is an N class of [10].
2. It was observed that the optimum level of replacement of cement by saw dust ash in concrete production is 10 %. Although this tendency was a little above the value obtained by [12] and [13].
3. The concrete obtained in this study with such replacements suggests that be revibrated up to 10 minutes to produce improved concrete strength quality.

4. Re-vibration increased the compressive strength of OPC-SDA concrete by completely eliminating void provided once carried out within the setting time of the concrete [2; 4; 5].

5. Re-vibration of concrete should be encourage in the production of concrete in other to ensure improvement in quality such as strength of the concrete if it does not exceed the plastic range.

6. Ten percentages (10 %) SDA replacement of SDA should be employ in the production of light weight concrete. This will also improve effective agricultural waste management and the economic base of the farmer.

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